Chapter 6 – Random Numbers

Randomness is something most people seem to have an intuitive sense about. But truly random values are surprisingly hard to get. In fact, calculators (and computers) can't generate true random numbers since any values they obtain are based on an algorithm (that is, a program). But they do give good *pseudorandom* numbers. These have many applications from simulation to selecting samples and assigning treatments in an experiment. Random selection (and random number generation) form the basis of sample selection (choosing randomly from the population) and treatment assignment in experiments (to avoid bias.)

SIMULATIONS

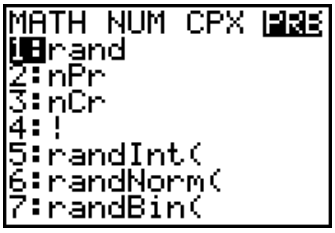
Simulations are used to mimic a real situation such as this. Suppose a cereal manufacturer puts pictures of famous athletes in boxes of their cereal as a marketing ploy. They announce that 20% of the boxes contain a picture of Tiger Woods, 30% a picture of David Beckham, and the rest have a picture of Serena Williams. Assuming the pictures are distributed in the boxes at random in the specified ratios, how many boxes of the cereal do you expect to have to buy in order to get a complete set?

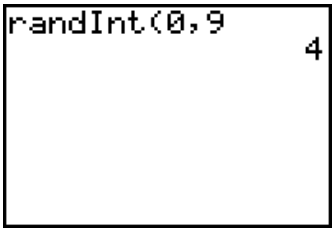
You could go out and buy lots of cereal, but that might be expensive. We'll model the situation using random numbers, assuming the pictures really are randomly placed in the cereal boxes, and distributed randomly to stores across the country.

We'll use random digits to represent getting the pictures: since 20% have Tiger's picture, we'll let the digits 0 and 1 represent getting his picture. Similarly, we'll use digits 2, 3, and 4 (30% of the ten digits) to represent getting Beckham's picture. The rest (5 through 9) will mean we got a picture of Serena. We need to get the random digits.

TI-83/84 Procedure

From the home screen, press [MATH], then arrow to PRB. The menu at right is displayed. We want choice 5:randInt(. Either arrow to it and press [ENTER] or simply press [5]. The command shell will be transferred to the home screen. Now you need to tell the calculator the boundary values you want. Since we want digits between 0 and 9, we will enter [0][,][9] . Pressing [ENTER] will get the first random digit.

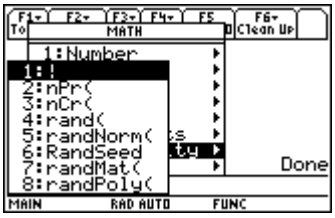




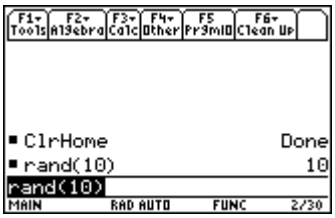
Here is our first random digit: a 4. That means the first box had a picture of Beckham. We can continue pressing [ENTER] and get more random digits.

TI-89 Procedure

From the home screen, press [2nd][5] (MATH), then arrow to 7:Probability. Pressing the right arrow displays the menu at right. We want choice 4:rand(. Either arrow to it and press [ENTER] or simply press [4]. The command shell will be transferred to the home screen. This command generates numbers between 1 and the value specified, so here we would renumber our possibilities and consider a 1 or 2 as getting Tiger's picture; 3, 4, or 5 Beckham's picture, and values 6 through 10 as Serena's picture. Since we want numbers between 1 and 10, we will enter [1][0][)] . Pressing [ENTER] will get the first random number.



Here is our first random number: a 10. That means the first box had a picture of Serena. We can continue pressing [ENTER] and get more random digits.

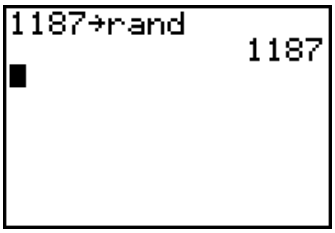


In general, for random integers between 1 and *N*, the parameter for the rand command is *N*.

CONTROLLING THE SEQUENCE OF RANDOM DIGITS

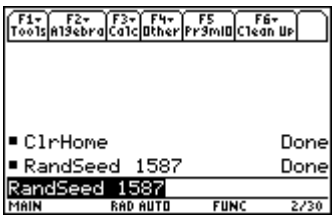
You didn't get the same random number? Not surprising. Random number generation on computers and calculators works from something called a *seed*. In the case of TI calculators, every command you use changes the seed. If a value is explicitly stored as the seed *immediately before* a random number command, the sequence of random digits will be the same every time.

To store a seed, enter the value desired, then press [STO▸][MATH], then arrow to PRB and press [ENTER]to select rand then press [ENTER] again to actually store the seed. The sample at right stored 1187 as the seed.

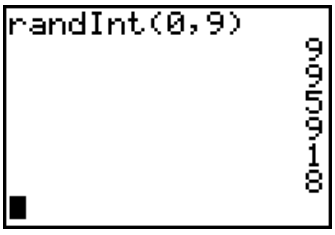


Good seeds are large, preferably prime (or at least odd) numbers.

To store a seed on a TI-89, go to the Math, Probability menu as before, but select choice 6:RandSeed. Type in the desired seed value and press [ENTER]. Here, the seed value is 1587. Press [CLEAR] to erase the command from the entry area.

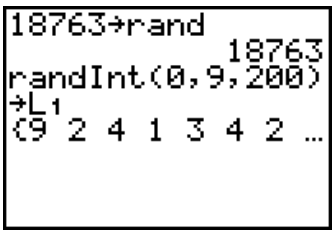


Follow setting the seed with the same random integer command as before, and we get values as shown at right. Yours should be the same. Look at the first five numbers. These correspond to (in our example above) getting Serena, Serena, Serena, Serena, Tiger, and Serena. Even after the sixth "box" we haven't gotten all three pictures. In fact, it takes two more boxes (another Tiger then finally a Beckham) for a total of eight boxes to get the complete set.

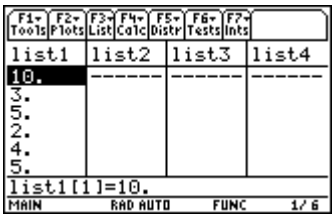


One simulation is not a very good representation. We'd like to know how many boxes it would take to get all three, *on average*. We need to repeat the simulation many times, and take the average value from the many simulations. We could just keep pressing [ENTER] until we've done enough, or we can get many random numbers at once and store them into a list.

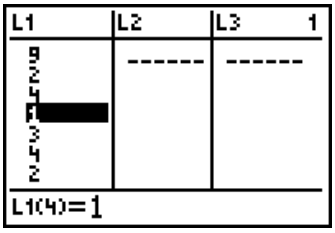
Here, we've reset the seed to 18763 and changed the random integer command to add another parameter – how many numbers to generate. Since it could possibly take many boxes of cereal to get all three pictures, we've chosen to store 200 numbers into list L1. (Press [STO▸][2nd][1] after the ending parenthesis on the random integer command.) The first few values are displayed. To see the rest, use the Statistics Editor.



On a TI-89, inside the Statistics Editor, move the cursor to highlight the name of a list. Press [F4] then [4] for Probability and select choice `5:randInt(`. The parameters are the low number to be generated, the high end of the desired numbers, and how many. End the command by closing the parentheses. Since it could possibly take many boxes of cereal to get all three pictures, we've chosen to store 200 numbers into list1. Pressing [ENTER] executes the command and fills in `list1`. To set the seed here, select menu option `A:RandSeed` from the Probability menu.



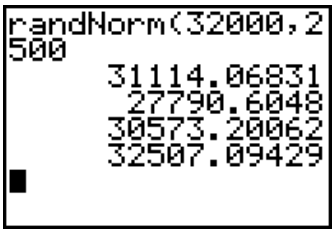
Looking at the list in the editor, the first four digits are 9, 2, 4, and 1. That corresponds to a Serena, Beckham, Beckham, and Tiger. That trial took four boxes to get the full set. One can continue down the list until several complete sets have been found; then compute the average for all trials as the estimate of the average number of boxes.



RANDOM NORMAL DATA

These calculators can also simulate observations from normal populations in a manner similar to the examples above. The command is choice `6:randNorm(` from the `Math`, `Prb` menu. The parameters are the mean and standard deviation.

This example models the following: A tire manufacturer believes that the tread life of their snow tires can be described by a Normal model with mean 32000 miles and standard deviation 2500 miles. You buy 4 of these tires, hoping to drive them at least 30000 miles. Estimate the chances that all four last at least that long. We have output for one trial – a set of four tires. In this trial, 3 of the 4 lasted over 30000 miles. To further estimate the chance that all four last over 30000 miles, obtain more repetitions of sets of four tires.



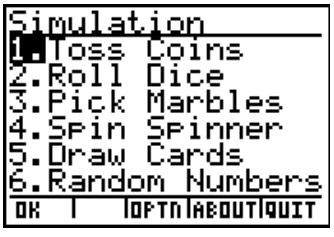
With a TI-89, random normal data are option 6 on the Probability menu in the Statistics/List Editor application. Specify the mean, standard deviation, and the number of values you want similarly to the random integer command.

SAMPLING AND TREATMENT ASSIGNMENTS

Random numbers are the best method for (randomly!) selecting items or individuals to be sampled or treatments to be assigned in an experiment. In the sampling frame (a list of members of the population) number the individuals from 1 to N, where N is the total number in the list. Use the Random integer command to select those to be sampled. In the case of assigning treatments, if there are, for example two treatments, use random integers to assign half the experimental units to treatment A; the rest will get treatment B.

THE PROB SIM APPLICATION

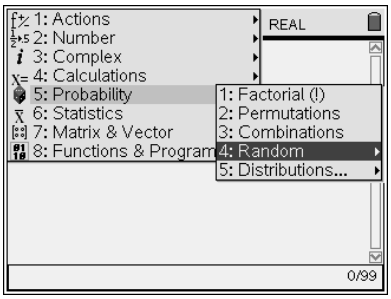
TI-83+ Silver Edition calculators and the TI-84 series also come with the Prob Sim application. Press [APPS]. From the list of applications, select Prob Sim. Press [ENTER] to select it, then any key to get the simulation main menu.

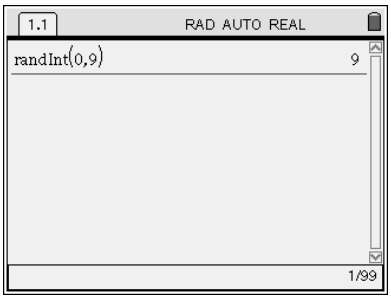


We can use menu option 6 to mimic the room lottery drawing in the text. Press [6] then [ZOOM](`Set`) to set the parameters for the simulation. There are a total of 57 students, of which we will consider numbers between 1 and 20 to represent the varsity athletes. Any number 21 or larger will be a regular student. On the set-up screen, tell the simulator you want 3 numbers at a time between 1 and 57 with no repeats, then press [GRAPH] for `OK`. Press [WINDOW] (`Draw`) repeatedly to draw the room lottery numbers. Follow the program prompts to exit the simulator, change parameters, or change simulations. Unfortunately, this application turns off screen capture, so I can't show you my results.

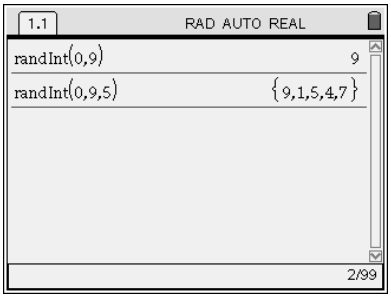
Commands for the TI-Nspire™ Handheld Calculator

To generate random integers, start on a Calculator page. Press (menu), and then select Probability, Random, and Integer. Place the lower and upper bounds in the command and (enter).

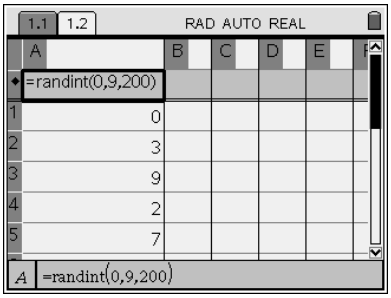




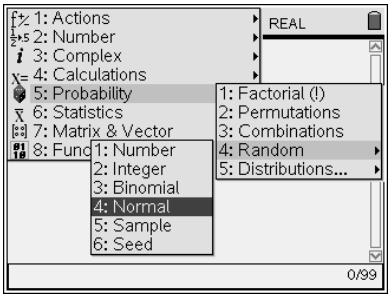
To create a list of random integers on the Calculator page, add an optional third parameter to the randInt command.

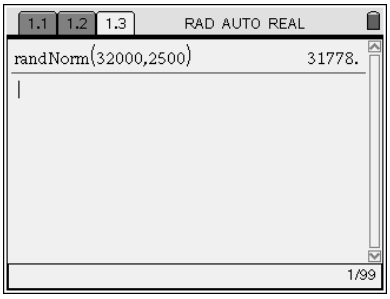


To create a list of random integers in a spreadsheet, start with a Lists and Spreadsheet page. On the formula row type the formula, such as =randInt(0,9,200).



To simulate a random value from a normal distribution, start on a Calculator page. Press (menu), and then select Probability, Random, and Normal. Place the mean and standard deviation in the command and (enter).





To simulate a list of random values from a normal distribution, add an optional third parameter.